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Effects of Supplementation with Different Levels of Wheat Bran and Noug Seed (*Guizotia abissynica*) Cake Mixtures on Performance of Hararghe Highland Sheep Fed a Basal Diet of Maize Stover

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Abstract
This study was conducted with the objectives to determine feed intake, digestibility, body weight gain and carcass characteristics in Hararghe Highland Sheep fed untreated maize stover (UMS) and supplemented with different levels of wheat bran (WB) and noug seed cake (NSC) mixtures in 2:1 ratio, and its comparison with sole urea treated maize stover (UTMS). Urea treatment increased crude protein content of maize stover by about 71%. Supplementation with concentrate mix increased ($p<0.001$) total DM intake (g/h/day). Average daily body weight gains of 50.2, 49.8 and 60 g/h/day was recorded for T3, T4 and T5, respectively, whereas T1 and T2 lost body weight. The final body weight, daily body weight gain and feed conversion efficiency were higher ($p<0.001$) for the supplemented groups compared to the control treatments. The SW, EBW, HCW and REA were significantly higher ($p<0.001$) in the supplemented sheep than non-supplemented. The current study revealed that ad libitum feeding of untreated MS with small amount of protein feed supplementation, and sole urea treated MS resulted in loss of body weight. However, supplementation of untreated maize stover with concentrate improved ram performance.

1. Introduction

Ethiopia is a home for about 54 million cattle, 25.5 million sheep and 24.06 million goats [5]. Sheep production is an integral component of the mixed crop-livestock production systems in Ethiopia. Sheep are primarily owned by smallholder farmers and contribute significantly to the economy and food supply of the poorest sectors of the society.

The major factors that affect the productivity of small ruminants in Sub-Saharan Africa (SSA) are feed supply, genotype, animal management, policy and institutional constraints [8].

Crop residues, such as stover and straws can play an important role in feeding of sheep in all management systems. Usually the nutritive value of most crop residues is low mainly because they are deficient in nitrogen, energy and high proportion of cell wall constituents, poor digestibility and low intake, so they have to be supplemented when fed to ruminants or their quality must be improved before feeding. Maize stover is widely used in commercial agriculture and it is an important cereal stover for livestock feed. However, its feeding value is limited by its deficiencies in crude protein, metabolizable energy and minerals [13]. Urea ammoniation offers an avenue to improve the nutrient quality and feeding values of stover and straws [3]. It increases the nitrogen content of low quality roughages [9]. There is limited information on supplementation using mixtures of agro-industrial by-products for sheep fed untreated crop residues like maize stover. The availability and cost of chemicals make treatment of low quality roughages impractical for farmers practicing zero grazing. Therefore, supplementing with fermentable energy and nitrogen could be a more attractive option [16].

Therefore, the current study was designed to investigate the effect of concentrate supplementation to untreated maize stover basal diet on animal performance with the objective of evaluating feed intake, digestibility, body weight change and carcass characteristics in Hararghe Highland Sheep fed maize stover (UMS) supplemented with different levels of wheat bran and noug seed cake mixtures.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at Haramaya University, which is located at 515 km east of Addis Ababa. The site is located at an altitude of 1980 meters above sea level with geographical coordinate of 9°N and 4°E longitude. The mean annual rainfall is 780 mm and the mean annual maximum and minimum temperature is 23.4°C and 8.25°C, respectively [11].

2.2. Experimental Animals and Management

Twenty five intact male uniform Hararghe Highland sheep with a mean initial body weight of 17.1±1.2 kg (mean ± SD) were purchased and quarantined for 21 days. At the end of this period, the sheep were de-wormed and sprayed against internal and external parasites and vaccinated against common diseases. Following the quarantine period, the animals were moved to experimental pen and confined in individual pens and fed the experimental ration for another 15 days of adaptation period.

2.3. Experimental Design and Treatments

The experiment was conducted by using RCBD in which sheep were blocked based on their initial body weight in to 5 blocks consisting of five animals. Each animal within each block was randomly assigned to one of the 5 treatments. The concentrate was mixed by machine mixer at 2:1 (WB: NSC) ratio. Untreated maize stover + 60g NSC (control A, T1) and urea treated maize stover alone (control B, T2) were expected to fulfill the maintenance requirement of the animals. The lowest level of concentrate mix supplement (150g) was expected to provide additional nutrients to support 43.3g average daily gain [15].

The treatments were; T1 (control A) = Untreated maize stover +60g NSC, T2 (control B) = Urea treated maize stover alone, T3 = untreated maize stover +150g CM, T4 = untreated maize stover +250g concentrate mix, and T5 = untreated maize stover +350g concentrate mix

2.4. Urea Treatment of Maize Stover

Maize stover was chopped to a length of 5-10 cm using tractor mounted chopper. One pit with a dimension of 1m×2m×1m was dug. A polyethene sheet laid the floor and the sides of the pit. A solution of 4 kg urea in 100 liters of water was prepared to treat 100 kg of DM of maize stover [6], [7]. The urea solution was uniformly sprayed using watering cans and mixed with the chopped stover. The treated stover was placed in the pit and trampled with feet and placed until the pit was full. Then the pit was covered with a plastic sheet and compacted with soil and stone and was left for 21 days. After 21 days, the pit was uncovered and aerated for a day in order to remove excess ammonia [18].

2.5. Measurements and Observation

2.5.1. Feed Intake

Feed offered and refused corresponding to each treatment diet from each sheep was recorded daily throughout the experimental period to determine daily intake of individual animal. A grab of representative sample was collected daily per batch of feed offered. Samples of feed refused were collected from individual animal, weighed and mixed per treatment, and both of them were sub-sampled to analyze chemical composition. Daily feed intake of experimental animals was calculated on DM basis as the difference between the feed offered and refused. The ME intake of experimental animal was estimated from its digestible organic matter intake (DOM) by using the equation given below [10].

ME=DOMD (g/Kg DM) X 0.0157, Where DOMD =Digestible organic matter per kg dry matter, DOMDI = (Organic matter in feed - Organic matter in feces)/Organic matter in feed

2.5.2. Body Weight Change

The body weight of each sheep was measured at 10 days interval in the morning after overnight withdrawal of feed to account for differences in gut fill. The feed which was not consumed until 6 pm was removed and weighed. Average daily body weight change was calculated as the difference between the final and initial body weight of the sheep divided by the number of experimental days. Feed conversion efficiency was calculated as a proportion of average daily weight gain to daily feed intake.

2.5.3. Digestibility

At the end of the feeding trial, all the sheep were harnessed with fecal bag to collect feces. Feces were collected for 7days and each day collection per animal was weighed and 20% was sub-sampled and stored frozen at -20 °C, and pooled per treatment over the collection period. Feed samples were taken on batches of feed offered and that of the refusal was taken for each animal daily and pooled per treatment. Samples of the feed ort for individual animals during digestion trial were also separately collected. Composite samples of feces were thawed to room temperature, mixed thoroughly and the required amount of sample was dried at 55°C for 72 hours. The dried samples of the feces was ground through 1 mm sieve and stored in airtight polyethylene bag until being analyzed.

2.5.4. Carcass Characteristics

At the end of digestibility trial, all the sheep were fasted overnight, weighed and slaughtered and their carcass parameters were evaluated. The empty body weight (EBW) of each animal was calculated as the difference between slaughter weight (SW) and gut content. Total edible offal components (TEOC) were taken as the sub total of the blood, heart, liver with gall bladder, empty gut, kidney, tongue, tail and the testis and fat (omental and kidney). Total non-edible offal component (TNEOC) was considered as the sum of the weight of head, lung with trachea, skin, penis, spleen, feet and gut content. Hot carcass weight was computed by excluding thoracic, abdominal and pelvic cavities, head, skin with feet and tail of the animal. Dressing percentage was calculated as proportion of hot carcass weight (HCW) to slaughter weight (SW) and empty body weight (EBW). The rib-eye muscle area of each animal was determined by tracing, the cross areas of 11th and 12th ribs after cutting perpendicular to the back bone. The mean of the right and left cross-sectional areas was taken as a rib-eye muscle area.

2.6. Chemical Analysis

Chemical analysis of the offered and refused feeds in the experiment as well as feces excreted in digestibility trial was subjected to laboratory for analysis. The dry matter, organic matter, nitrogen and ash content of the samples were determined following the procedure of [2]. The ADF, NDF and ADL component of each ingredient and feces were determined by using the procedures of [17]. The CP content was estimated as N×6.25.

2.7. Statistical Analysis

The data obtained on feed intake, body weight change, digestibility and carcass parameters were subjected to analysis of variance (ANOVA) using the General Linear Model procedure of [13]. To describe the effect of CP intake on average daily live weight gain of Hararghe Highland sheep, regression analysis was used.

The model for the experiment was:

$$y_{ij} = \mu + \alpha_{ii} + b_j + e_{ij}$$

Where: y_{ij}= response variable
μ = over all mean
α_{ii} =ith treatment effect
b_j= jth block effect
e_{ij}=random error

3. Results and Discussion

3.1. Sensory Evaluation of Ensiled Maize Stover

Sensory evaluation is one of the methods to evaluate the quality of ammoniated maize stover. In the current study, the treated maize stover had a strong and pungent smell that indicates the efficiency of the treatment. There was no mould growth on treated stover. Its color was brownish yellow and it was soft in texture, showing uniform application of urea solution to the stover.

3.2. Chemical Composition of Experimental Feeds

Table 1. *The chemical composition of the feeds offered and refused during the experiment.*

Chemical composition (%DM)	Treatment feeds				
	UTMS	UMS	WB	NSC	WB:NSC (2:1)
DM	94.9	92.3	92.2	92.3	92.3
Ash	7.3	9.9	7.5	13.8	11.4
OM	91.6	90.1	92.5	86.2	88.6
CP	7.9	4.6	19.4	29	20.1
NDF	75.7	82.8	57.2	38.3	48.1
ADF	43	49.3	11.2	27	20.5
ADL	3.7	5.2	3.6	4	3.7
Chemical composition (%DM)	Refusal maize stover				
DM	T1	T2	T3	T4	T5
	90.4	92.7	88.6	90.7	90.7
Ash	12.2	8.7	11.1	11.1	11.2
CP	2.3	3	2	2.7	2.1
OM	87.67	91.32	88.9	88.9	88.85

DM = dry matter; OM = organic matter; CP = crude protein; NDF = Neutral detergent fiber; ADF= acid detergent fiber; ADL = acid detergent lignin.

The CP content of urea treated maize stover in the current study was 7.9%. The variation from other studies in the CP content of treated maize stover in different studies may be due to factors that play role for the effectiveness of urea treatment, which includes variety difference, stage of harvesting, urea dose, and moisture content of the stover, treatment time and temperature.

3.3. Feed and Nutrient Intake

The mean daily basal, supplement and total feed dry matter intake of Hararghe Highland sheep are presented in Table 2. The daily basal dry matter intake of T2 was significantly higher ($p<0.001$) than the other groups. This implies that urea treatment increased the daily feed intake of maize stover. Animals in T5 had significantly lower untreated maize stover intake than animals in T1, but T1, T3, and T4 consumed statistically the same amount of untreated maize stover, which shows that intake of maize stover is significantly reduced only at higher level of concentrate supplementation. The total dry matter intake (TDMI) was the same between T1 and T2, but total dry matter intake increased significantly ($p<0.001$) with increasing level of concentrate supplementation. Thus, the TDMI was positively related to the level of concentrate mixture supplementation.

Dietary protein supplementation is known to improve intake by increasing the supply of nitrogen to rumen microbes. This has a positive effect of increasing microbial population and efficiency, thus enabling them to increase the rate of digestion.

The daily total dry matter intake expressed as g/kg $W^{0.75}$ was lower ($p<0.001$) in T3 than all other treatments. Similar intake of dry matter in metabolic body weight base of T1 and T2 compared to T4 and T5 is attributed to body weight loss in the former treatments compared to the later treatments.

Table 2. *Feed dry matter and nutrient intake of Hararghe Highland sheep fed a basal diet of maize stover supplemented with different levels of wheat bran and noug seed cake mixtures.*

Parameters	**Treatments**						
Feed DMI	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**	**SL**
Maize stover	597.7^{b}	630.7^{a}	566.6^{bc}	566.1^{bc}	542.8^{c}	10.11	***
Supplement	60^{d}	0	150^{c}	250^{b}	350^{a}	0.00	***
Total DMI (g/d/head)	657.7^{d}	630.7^{d}	716.6^{c}	816.1^{b}	892^{a}	10.11	***
TDMI (g/kg$W^{0.75}$)	82.8^{a}	87.2^{a}	71.5^{b}	81.7^{a}	85.8^{a}	2.31	***
DMI (%BW)	4.1^{ab}	4.5^{a}	3.3^{c}	3.8^{b}	4^{b}	0.14	***
Nutrient intake (g/day)							
ME (MJ/head/day)	5.4^{d}	5.7^{d}	6.9^{c}	7.7^{b}	8.4^{a}	0.19	***
TOMI	586.3^{d}	587.3^{d}	638.9^{c}	715.1^{b}	774.8^{a}	8.37	***
TCPI	43.8^{e}	50.1^{d}	55.7^{c}	71.2^{b}	88.9^{a}	0.55	***

DMI = dry matter intake; OMI = organic matte intake; CPI = crude protein intake; AshI = Ash intake; NDFI = Neutral detergent fiber intake; ADFI = acid detergent fiber intake; ADLI = acid detergent lignin intake; SEM =standard error of mean; SL=significance level.

Table 3. *Apparent dry matter and nutrient digestibility of Hararghe Highland sheep fed a basal diet of maize stover supplemented with different levels of concentrate mixture.*

Treatments							
Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**	**SL**
Nutrient intake							
DMD	60.8^{c}	65.2^{b}	69.7^{a}	70.4^{a}	71.5^{a}	0.97	***
OMD	58.7^{b}	62.1^{b}	68.6^{a}	68.5^{a}	69.5^{a}	1.10	***
CPD	77.1^{c}	75.3^{c}	80.9^{b}	83.6^{ab}	85.9^{a}	0.89	***
NDFD	58.2^{b}	67.01^{a}	65.2^{a}	64.7^{a}	64.6^{a}	0.79	***
ADFD	59.6^{c}	70.1^{a}	68.9^{a}	63.9^{b}	61.6^{bc}	1.00	***
Digestible nutrient intake (g/h/d)							
DDMI	397.2^{d}	411.5^{d}	492.1^{c}	560.7^{b}	619.4^{a}	16.66	***
DOMI	346.9^{d}	364.3^{d}	441.3^{c}	492.5^{b}	538^{a}	15.57	***
DCPI	33.8^{e}	37.8^{d}	45.1^{c}	59.6^{b}	76.3^{a}	3.32	***
DNDFI	283.2^{c}	360.4^{a}	318.3^{b}	343.8^{ab}	346.7^{a}	8.58	***
DADFI	167.6^{d}	238.5^{a}	203.7^{b}	186.7^{c}	182.2^{cd}	4.42	***

DDMI = Digestible Dry matter intake; DMD= dry matter digestibility; DADFI= digestible acid detergent fiber intake; DNDFI=digestible neutral detergent fiber intake; DCPI= digestible crude protein intake; DOMI= Digestible organic matter intake; OMD=organic matter digestibility; ADFI= acid detergent fiber intake; NDFI= neutral detergent fiber intake; SEM =standard error of mean; SL=significance level

3.4. Nutrient Digestibility

The apparent digestibility and digestible nutrient intake of DM, OM, CP, NDF and ADF are presented in Table 3. Overall, the apparent digestibility of DM in T1 was less than 65%, indicating its relatively low digestibility as compared to the other treatments (T2, T3, T4 and T5), which have moderate to high digestibility of nutrients. In the current study, it was observed that supplementation improved ($p< 0.001$) DM, OM, CP, and NDF digestibility of T3, T4, and T5 groups as compared to sheep fed sole urea treated maize stover *ad libitum* (T2) and that consumed untreated stover and 60 g NSC. The lower digestibility of nutrients in T1 and T2 might be related to the lower CP content of the maize stover. The DM, NDF and ADF digestibility in T2 were higher ($p<0.001$) than T1, but no significant difference was observed in CP and OM digestibility. Digestible CP intake was higher ($p<0.001$) in T2 (37.8g/day) than T1 (33.8g/day), however, in both treatments it is still below 38g/day DCP recommended for maintenance requirement of growing sheep in the tropics [12].

3.5. Body Weight Change

Table 4. Body weight change of Hararghe highland sheep fed a basal diet of maize stover supplemented with different levels of concentrate mixtures.

Treatments							
Parameters	T1	T2	T3	T4	T5	SEM	SL
IBW (kg)	17.1[a]	16.96[a]	16.94[a]	17.32[a]	17.2[a]	0.24	ns
FBW (kg)	15.4[b]	14.5[b]	21.5[a]	21.8[a]	22.6[a]	0.79	***
ADG (g/day)	-18.8[b]	-26.9[b]	50.2[a]	49.8[a]	60[a]	0. 008	***
FCE	-0.03[b]	-0.04[b]	0.08[a]	0.09[a]	0.1[a]	0.0001	***

IBW= Initial body weight; FBW= final body weight; ADG= average daily gain; FCE= feed conversion efficiency; SEM =standard error of mean; SL=significance level

The final body weight, average daily body weight gain and feed conversion efficiency showed no significant difference among supplemented groups and between the controls. Lack of significant differences among supplemented sheep reflects that the different levels of supplements were comparable in their potential to supply nutrients for improving the growth performance of the sheep. These results indicated that diets which have higher digestibility values result in higher final body weight gain, average daily gain and feed conversion efficiency. This also confirmed that the supplements have relatively higher nutrient concentrations that contribute to increment in body weight gain. T1 and T2 lose body weight at the end of the experiment, which is attributed to the low nutrient density extracted from basal diets of treated and untreated maize stover that did not fulfill the maintenance requirement of the animals, thus they were forced to lose their body reserve. Although there was an improvement in CP content of urea treated maize stover, it did not prevent body weight lose indicating that increment in CP content does not necessarily imply a good treatment effect, rather it may show the presence of residual urea that resulted from partial ureolysis, where all urea nitrogen is not hydrolyzed to urea gas [4].

Animals fed with urea treated maize stover alone lost numerically higher body weight than those consumed untreated maize stover and supplemented with 60g NSC. This result reveals that urea treatment of roughage feeds may not have biological advantage as compared to small amounts of concentrate supplementation. Thus, careful consideration should be a prerequisite before making decision to treat or supplement crop residues both in terms of animal performance and economics of feeding.

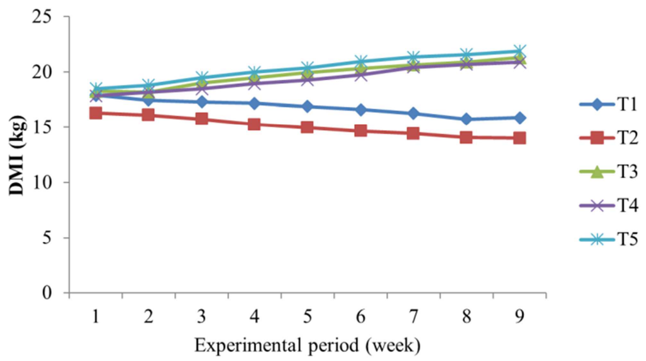

Figure 1. *Trends in body weight change of Hararghe Highland sheep fed a basal diet of maize stover and supplemented with different levels of concentrate mixture.*

As shown in Figure 1 animals in the supplemented treatments maintained their body weight in the first 10 days and thereafter started steadily gaining their body weight along the experimental period while animals in control groups, T1 and T2, continuously loss body weight throughout the experimental period. The linear regression between the dependent variable of daily body weight gain, and the independent variable of CP as % of DM (Figure 2), indicated the importance of protein supply as the primary determinant of the growth of sheep fed basal diet of maize stover-based diets. [1] reported that goats supplemented with a concentrate mix gained more weight compared with non-supplemented ones.

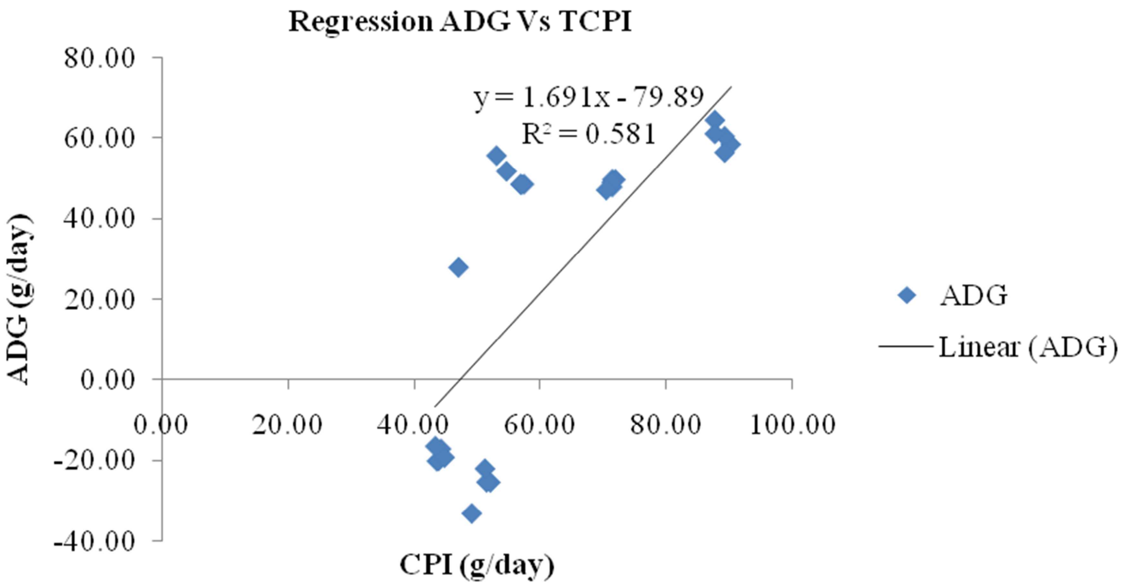

Figure 2. *The regression of average daily gain along total crude protein intake of Hararghe Highland Sheep fed maize stover and supplemented with different levels of wheat bran and noug seed cake mixtures.*

3.6. Carcass Characteristics

Mean values of slaughter weight, empty body weight, hot carcass weight, dressing percentage and rib-eye area of Hararghe Highland sheep fed maize stover supplemented with wheat bran and noug seed cake mixtures were presented in Table 5. Supplemented sheep had significantly higher ($p<0.001$) slaughter body weight, empty body weight, hot carcass weight and rib-eye muscle area than sheep in the control groups (T1 and T2). This clearly reveals that supplementation had a positive effect on SW, EBW, HCW and REA. This also indicates that sheep supplemented with concentrate mixtures were able to develop a better muscle than the controls.

Table 5. *Effects of supplementation of maize stover with wheat bran and noug seed cake mix on carcass characteristics of Hararghe Highland sheep.*

Treatments							
Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**	**SL**
SW (kg)	15.2^{b}	14.5^{b}	21.3^{a}	21.5^{a}	22.3^{a}	0.70	***
EBW (kg)	11.7^{b}	11.2^{b}	18.3^{a}	17.9^{a}	18.7^{a}	1.74	***
HCW (kg)	5^{b}	4.8^{b}	7.7^{a}	7.8^{a}	8.2^{a}	0.76	***
Dressing percentage							
SBW base	33^{b}	33.2^{b}	35.2^{ab}	36.2^{a}	36.8^{a}	1.00	*
EBW base	43.1^{a}	43^{a}	42^{a}	43.8^{a}	44.2^{a}	1.01	ns
REA (cm^2)	4.2^{c}	3.88^{c}	6.04^{b}	6.34^{ab}	7.28^{a}	0.73	***

SW = Slaughter weight; EBW = Empty body weight; HCW =Hot carcass weight; SBW base = Slaughter body weight base; REA = rib- eye muscle area; SEM =standard error of means; SL = significance level;

The current study indicated that dressing percentage in slaughter body weight base was higher ($p<0.05$) in the supplemented treatments than the non-supplemented. Animals in T4 and T3 showed significantly higher ($P<0.05$) DP on slaughter weight base than animals in T3. Sheep fed T1 and T2 showed no significant difference between them. DP on empty body weight base showed no significant difference between supplemented and non-supplemented treatments.

4. Summary and Conclusion

The study was conducted to evaluate the effect of supplementation of graded levels of concentrate mix consisting of wheat bran and noug seed cake mixed at a ratio of 2:1, respectively, on performance of Hararghe Highland Sheep fed maize stover. The study consisted of feeding and digestibility trials of 90 and 7 days, respectively and 25 male intact Haraghe Highland Sheep with initial average body weight of 17.1±1.2 kg (mean ± SD). The experiment was conducted using a randomized complete block design (RCBD) with five treatments. The treatments used in the experiment were untreated maize stover +60g NSC (T1), urea treated maize stover alone (T2), untreated maize stover +150g concentrate mix (T3), untreated maize stover +250g concentrate mix (T4), untreated maize stover +350g concentrate mix (T5) on DM basis. The treatments were assigned randomly to each experimental sheep within a block.

The CP content of untreated maize stover, wheat bran and NSC is 4.6, 19.4 and 29% CP, respectively. The daily mean total maize stover DM intake of sheep in the control group T1 was significantly higher ($p<0.001$) than supplemented groups. Sheep on the supplemented group had a higher ($p<0.001$) total DM, OM and CP intake. The CP intake and digestibility for high level of concentrate mix supplementation was significantly higher ($p<0.001$) than the other levels of supplementation and the control treatments. Supplementation significantly improved ($p<0.001$) the digestibility of CP. The average daily body weight gains of -18.8, -26.9, 50.2, 49.8 and 60g/head/day was observed for T1, T2, T3, T4 and T5, respectively. The final body weight, average daily gain and feed conversion efficiency of supplemented treatments were higher ($p<0.001$) than the controls. All the concentrate supplemented animals utilized their feed efficiently ($p<0.001$) compared to the control, which could be due to the higher level of nutrients in the supplement feeds. Generally, it is concluded that supplementation with mixtures of wheat bran and noug seed cake at 2:1 ratio to basal diet of maize stover improved both DM and CP intake, DM and CP digestibility and performance of Hararghe Highland Sheep.

From biological point of view, sheep producers can use the supplement feeds in the order of T3, T4 and T5, respectively. Moreover, sheep on the highest level of supplementation (T5) returned the highest profit compared to the other supplemented treatments. Hence, the diet with 350g/day could be recommended as a profitable level if capital is not a constraint. On the other hand, when there is capital constraint the diet with 150g/day concentrate mix could be the economical optimum level.

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